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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

33774

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/869635

INTERNATIONAL APPLICATION NO.  
PCT/FR00/00108INTERNATIONAL FILING DATE  
19 January 2000 (19.01.00)PRIORITY DATE CLAIMED  
20 January 1999 (20.01.99)

## TITLE OF INVENTION

"PROCESS AND DEVICE FOR DISCRIMINATING NUCLEAR FUELS"

## APPLICANT(S) FOR DO/EO/US

LEBRUN, Alain; BIGNAN, Gilles; VAUBAILLON, Sylvain.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
  - b. ☒ has been communicated by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
  - a. ☒ is attached hereto.
  - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
  - b. ☐ have been communicated by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

## Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:

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U.S. APPLICATION NO (if known see 37 CFR 1.5) <b>09/869635</b>		INTERNATIONAL APPLICATION NO PCT/FR00/00108		ATTORNEY'S DOCKET NUMBER 33774	
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21. <input checked="" type="checkbox"/> The following fees are submitted: <b>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):</b> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... \$1000.00  International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... \$860.00  International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$710.00  International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... \$690.00  International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) ..... \$100.00 <b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>				<b>CALCULATIONS PTO USE ONLY</b>          <div style="display: flex; justify-content: space-between;"> <span>\$ 860.00</span> <span></span> </div>	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				<div style="display: flex; justify-content: space-between;"> <span>\$ -0-</span> <span></span> </div>	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$ -0-	
Total claims	6 - 20 =	0	x \$18.00	\$ -0-	
Independent claims	2 - 3 =	0	x \$80.00	\$ -0-	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00	\$ -0-	
<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$ 860.00	
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				<div style="display: flex; justify-content: space-between;"> <span>\$ -0-</span> <span>+</span> </div>	
<b>SUBTOTAL =</b>				\$ 860.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				<div style="display: flex; justify-content: space-between;"> <span>\$ -0-</span> <span></span> </div>	
<b>TOTAL NATIONAL FEE =</b>				\$ 860.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +				<div style="display: flex; justify-content: space-between;"> <span>\$ 40.00</span> <span>+</span> </div>	
<b>TOTAL FEES ENCLOSED =</b>				\$ 900.00	
				Amount to be refunded:	\$
				charged:	\$

a. ☒ A check in the amount of \$ 900.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_ to cover the above fees.  
 A duplicate copy of this sheet is enclosed.

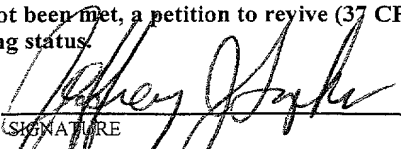
c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any  
 overpayment to Deposit Account No. 16-0820. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card  
 information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

Order No. 33774

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR  
 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:  
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 Jeffrey J. Sopko  
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 NAME  
 27676  
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 REGISTRATION NUMBER

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Alain Lebrun, et al.  
Serial No.: N/A  
Filed: Herewith  
Title: PROCESS AND DEVICE FOR DISCRIMINATING NUCLEAR FUELS  
Docket No.: 33774

PRELIMINARY AMENDMENT "A"

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir/Madam:

Please amend the above-identified application, prior to examination thereof, in the following manner.

IN THE CLAIMS:

Please cancel claims 1-6 without prejudice.

Please add new claims 7-12 as follows:

- 1           7. (new) Process for discriminating nuclear fuels from their composition, whereby
- 2       two types of radiation emitted by the fuel are measured, deducing the level of burn-up
- 3       (TC) of the fuel from the measured value (n) of one of the types of radiation, assuming
- 4       that the fuel has a defined composition, estimating an emission value for the other type
- 5       of radiation as a function of the assumed composition and the level of deduced burn-up
- 6       of the fuel, comparing this estimated emission value with the measured value ( $\gamma$ ) of the
- 7       other type of radiation, and concluding that the assumed composition of the fuel is the

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8 real composition if the values composed are similar, and that, if not, the fuel has another  
9 composition.

1 8. (new) Process for discriminating nuclear fuels according to claim 7, whereby  
2 one of the types of radiation is neutron radiation and the other type of radiation is gamma  
3 radiation over an emission energy range of at least one long life radioactive element.

1 9. (new) Device for discriminating nuclear fuels in an installation, comprising a  
2 structure subjacent to the storage cells immersed in a water filled bay, comprising a first  
3 detector, (15), of a first type of radiation, a second detector, (16), of a second type of  
4 radiation, a waterproof casing, (2), containing the detectors, whereby it contains the  
5 means of attaching the casing, (13, 14), to a boom, (3), that descends towards the fuel and  
6 the means of placing, (6, 9), the casing in a given position on at least one of the cells, (5),  
7 adjoining a cell containing the nuclear fuel, (26), that is the subject of the discrimination.

1 10. (new) Device for discriminating nuclear fuels according to claim 9, whereby  
2 one of the detectors is a gamma radiation detector located behind two collimators in  
3 continuation (25, 31; 32, 34), comprising a rear collimator, located just in front of the  
4 said detector and opening up onto the whole detection area of a detection body, and a  
5 front collimator, with a slot section extended in the transversal direction of a fuel  
6 element.

1 11. (new) Device for discriminating nuclear fuels according to claim 10, whereby  
2 the casing comprises a fixed part (36) bearing the means for attaching it, and a mobile

3 part, (38), that pivots around the fixed part in such a way as to turn the slot a quarter turn  
4 or a half turn.

1 12. (new) Device for discriminating nuclear fuels according to claim 10, whereby  
2 the slot has a variable extension dimension and broadens out towards the fuel element.

REMARKS

If there are any additional fees resulting from this communication not covered by the enclosed check, or if the check was omitted, please charge all uncovered fees to our Deposit Account No. 16-0820, our Order No. 33774.

Respectfully submitted,

PEARNE & GORDON LLP

By:

  
Jeffrey J. Sopko, Reg. No. 27676

526 Superior Avenue, East  
Suite 1200  
Cleveland, Ohio 44114-1484  
(216) 579-1700

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JCIS Rec'd PCT/PTO 02 JUL 2001

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# PROCESS AND DEVICE FOR DISCRIMINATING NUCLEAR FUELS

## DESCRIPTION

5 The invention concerns a process and a device for discriminating nuclear fuels from their initial composition, before they have been modified by burn-up.

10 Nuclear fuels normally contain uranium oxide as the fissile element. Another fuel, containing a mixture of uranium oxide and plutonium oxide, is however being more widely used. Devices are therefore needed to tell if a fuel element in a nuclear reactor contains a fuel of one or the other type. In order to do this, one can exploit the differences in the radiation that these fuels emit, but the  
15 difficulties that need to be overcome do not allow, at first sight, a certain diagnosis to be established.

20 Fuel only containing uranium oxide does not emit neutrons in the new or non-irradiated state, unlike fuel containing plutonium oxide. It therefore appears simple to discriminate between these two types of fuels using this criterion, but this becomes impossible with irradiated fuels, which all emit neutrons. Gamma radiation, also emitted by nuclear fuels, also does not enable them to be discriminated since its intensity is identical for both of  
25 the fuel compositions considered here, but it also depends very much on the irradiation of the fuel, and even the cooling time, when the fuel has been extracted from the reactor in order to be examined.

30 A device fitted with gamma and neutron radiation detectors exists, but it is not normally intended to discriminate between fuels. The radiation measurements are independent and are used to evaluate the level of radiation

or the burn-up fraction of the fuel in order to verify that it is not used up. The total gamma radiation is measured so that its drop off as a function of the cooling time can be used, and the level of burn-up is deduced from the form of the decreasing function.

If the composition of the fuel is not known accurately, the inventors of this prior device propose an "active" neutron method instead of measuring the neutron radiation emitted by the fuel: this method consists in having a source of neutrons beside the fuel and measuring the emission of neutrons that passes through the fuel; the device is divided into two parts on either side of the fuel, one of which holds the neutron source and the other the detector. The device therefore becomes bulky and not-transportable in practice; it therefore remains immobile and each fuel element is placed before it. This makes it necessary to extract each element (in general, a cluster of very long rods) from the cell in which it is stored, and to pass it in front of the device, before replacing it in its place. These lengthy manipulations make the measurement procedures fastidious, increase the inactivity time of the reactor and risk deteriorating the elements. One cannot accept working in this manner to discriminate between fuel elements, especially when substitutions with criminal intent are feared, in particular to steal plutonium, and where the person making the substitution can be very skilful and wish to hide his / her act by replacing the fuel by another with quite similar emission properties, or simply several rods of the assembly. The measurements must be precise and carried out with care, which makes it necessary to take the time to ensure they are made under correct operating conditions or to take additional measures

by precaution. One thus wishes to avoid lengthy handling of the fuel elements and to merely extract them partially from their cells, by transporting the device in front of each element.

5       It should be pointed out that the active neutron method is insensitive to the composition of the fuel, but that it does not provide information on this composition and that it replaces the method of measuring neutrons emitted by giving the same result.

10       Therefore it would be a good idea to meet the requirement for quite quick measurements for discriminating between fuels using a mobile device, and it should not be forgotten that the device and the fuel remain immersed and that it is therefore difficult to ensure the precise position of the device. A solution is proposed with the device that is the subject of the invention.

15       The proposed process differs from that of the prior device in that it is based on the correlation between two radiation measurements in order to obtain another result. It involves a process for discriminating nuclear fuels from their compositions, whereby it consists in measuring two types of radiation emitted by the fuel, deducing a burn up level of the fuel from the measured value of one of the types of radiation., assuming that the fuel has a defined  
20 (initial) composition, estimating an emission value for the other type of radiation as a function of the assumed composition and the burn up fraction deduced for the fuel, comparing this estimated emission value with the measured value of the other radiation, and concluding that the  
25 assumed composition of the fuel is the real (initial) composition if the composed values are similar and that, if not, the fuel has another composition.



In the case principally considered, one of the types of radiation is neutron radiation and the other type of radiation is gamma radiation over an emission energy band of at least one long life radioactive element.

5 In fact, although the gamma radiation varies in the same manner for the two fuel compositions as a function of the burn up fraction, the neutron radiation is always higher for the mixed fuel as the burn up fraction increases. The measured neutron radiation can therefore be  
10 linked to very different burn up fractions depending on the composition of the fuel, which can be correlated to very different gamma radiation activities, one of which one can be linked to the gamma activity measured by the other sensor in order to deduce the composition. The contribution  
15 from short half-life radioactive elements must however be ruled out, which depends on the cooling time of the fuel and the last irradiation power, in other words completely different parameters.

20 The preferred device for carrying out these measurements and this process comprises, apart from the detectors of the two types of radiation and a casing that contains them, means for attaching the casing to a boom that descends towards the fuel, stored in storage cells in a water filled bay, and means for positioning the casing in  
25 a given position on at least one of the cells, adjoining the cell containing the fuel that will be inspected. Such a device may be placed in a precisely defined position on the fuel storage structure, without having to worry about an error in its positioning or an unexpected movement, after  
30 which the fuel only has to be extracted slightly from the adjoining cell to place it at the same height as the detectors and to be able to carry out the inspection. The

device can then be transported to another fuel zone by moving the boom.

These aspects of the invention and others will now be described using the following figures:

- 5       • Figure 1 shows a longitudinal section of the device in its environment
- Figure 2 shows a cross section of the device
- Figures 3 and 4 show two enlarged longitudinal sections of the device
- 10      • Figure 5 shows an explanatory graph for the process
- And Figures 6 and 7 illustrate two possible improvements to the device.

Thus, as shown in Figure 1, the device, bearing the reference 1, is immersed in a water filled storage bay for cooling the fuel; it comprises a casing, 2, with a generally cylindrical shape, suspended from a handling boom, 3, which belongs to a system that already exists in the installation and which can be moved horizontally and vertically. The device, 1, can thus be placed on a structure, 4, of square or hexagonal cells, 5, for storing the nuclear fuel. As can be seen also from Figure 2, the system for placing the device, 1, on the structure, 4, comprises two tenons, 6, placed symmetrically to the front and rear of the casing, 1, and screwed to a communal base, 7, welded to the base of the casing, 2; the tenons, 6, comprise a plate, 8, and, laterally, two teeth, 9, that each fit into a corner of the cell, 5, and penetrate into this cell; the external edges, turned towards the structure, 4, of the teeth, 9, have a

clearance that allows them to be introduced without difficulty into the cells, 5, by lowering the boom, 3, then adjusting the position of the device, 1, when they touch the structure, 4.

5 An analogous set up can be used to ensure the attachment of the device, 1, to the boom, 3; a base, 11, is welded to the top of the casing, 2, and a gripping part, 12, is screwed into it; it has holds, 13, which grip onto the mobile catches, 14, of the boom, 3, which enable the  
10 device, 1, to be held firmly. It will have been understood that the gripping part, 12, and the tenons, 6, are screwed so that they can be replaced by parts with an analogous shape if the device, 1, has to be used with another boom, 3, or another structure, 4, on which it has to be set down.

15 The casing, 1, comprises (see also Figures 3 and 4) a neutron detector, 15, and a gamma radiation detector, 16, enclosed in the casing, 2. The neutron detector, 15, is composed of a fission chamber, 17, which converts the neutrons into electrical impulses, a thermalisation block, 18, which slows down the neutrons before allowing them to  
20 reach the fission chamber, 17, and which thus surrounds it, and an electrical connector, 19, joined to the fission chamber, 17. The gamma radiation detector, 16, comprises a narrow resolution crystal, 20, which signifies that it is  
25 only sensitive to photons with a well defined energy level. It can be a CdZnTe crystal, which is only sensitive to photons emitted by the isotopes of caesium ( $^{134}\text{Cs}$ ,  $^{137}\text{Cs}$ ); the detector, 16, also comprises an electrical connector, 21, attached to the crystal, 20. The connectors,  
30 19 and 21, transmit the electrical signals via the wire, 22, to a measuring unit, 41, located outside of the water filled storage bay, which evaluates the types of radiation

captured and enables the radiation output from the fuel to be deduced, or even to automatically apply the process described later. These wires, 22, pass through a waterproof plug, 23, which seals off the rear of the casing, 2. A lead or tungsten alloy shield, 24, surrounds the rest of the gamma radiation detector, 16, and comprises a collimator opening, forming a rear collimator, 25. This opening is conoidal, in other words in the form of a cone with an elliptic base whose largest axis of ellipse extends out in a horizontal direction or in the direction of the width of an assembly, 26, of nuclear fuel rods to be examined by the device, 1; this assembly, 26, is shown in the position for examination, partially extracted from a cell, 5, adjoining those on which the device, 1, is held. A boom, 27, analogous to the boom, 3, is used to carry out this extraction.

The casing, 2, is covered in the front by a specially shaped lead shield, 28, due to the gamma radiation, which the assemblies, 26, generally emit at an intensity a lot higher than the other. It comprises a thin, continuous part, 29, and which is placed in front of the neutron detector, 15, and a thick part, 30, with a slot, 31, in it, forming a front collimator, in front of the gamma radiation detector, 16, which, as can be seen, is placed behind the neutron detector, 15, but at a higher level in order not to get in its way. Under these conditions, the thin part, 29, of the shield, 28, protects the neutron detector, 15, from the gamma photons and the slot, 31, which extends over the whole width of the fuel assembly, 26, but is very thin in the other direction, and only allows a slight amount of radiation to pass towards the gamma radiation detector, 16, which is therefore not saturated; and the neutron detector,

15, is protected from the photons arriving from the top of the assembly, 26, by the thick part, 30, which covers it. The purpose of the opening, 25, of the rear collimator is also to stop part of the radiation that reaches it, but must all the same have a sufficiently large opening area at the bottom so that the crystal, 20, is exposed to the radiation. The gamma radiation detector, 16, can slide by rubbing up against the casing, 2, which allows its axial position to be adjusted and to adjust the overall collimation. It can be guided by rails, which are not illustrated.

The device, 1, as shown in Figure 1 is ready to operate, and by referring to Figure 5, it will immediately be obvious how the measuring principle works; the number of neutrons captured by the detector, 15, is the number,  $n$ ; the neutron activity curves for a uranium oxide assembly and an assembly containing a mixture of uranium and plutonium as a function burn up rate, or the irradiation of the assembly, are given in the curves  $n(U)$  and  $n(U, Pu)$ . If one assumes that the fuel is pure uranium oxide, one deduces that the burn up fraction is  $TC$ ; one then expects to measure an activity  $\gamma(U)$  using a  $\gamma$  curve which gives the activity as a function of the burn up fraction (this curve is valid for the two fuel compositions). If the activity measured by the detector, 16, is similar to this value, the initial assumption is confirmed; the fuel is indeed pure uranium oxide. If not, it is a mixture of oxides. Obviously, one can carry out another verification and also estimate the burn up fraction,  $TC'$ , for which the mixed fuel would give the measured neutron activity,  $n$ , then deduce from this the activity  $\gamma(U, Pu)$  that one should then

obtain and check if this value corresponds to that which is in fact measured. It is obvious that this process can be applied to discriminating more than two nuclear fuel compositions if one so desires, and even if their gamma radiation curves are different. Two other possible improvements are given in Figures 6 and 7. If the gamma radiation captured by the detector, 16, has to be further reduced compared to the solution represented above, one can change the collimation system and replace the slit, 31, of the shield, 29, by a fan shaped slit, 32, which opens out towards the assembly, 26, of the fuel in the direction of its width (the vertical direction in Figure 6). The height of the slit, 32, is identical to that of slit 31. The collimated radiation converges towards a focal point, 33, which can be located behind or in front of the gamma radiation detector, 16; the opening of the rear collimator, here given the reference 34, is at an identical angle to that of the front slot, 32, and if the rear collimator is located behind the focal point, 33, the opening, 34, opens up towards the crystal, 20. This construction makes it possible to reduce the quantity of radiation captured by the crystal, 20, while at the same time conserving the advantage that the slot, 34, opens out onto the whole surface of the crystal, 20, and the slot, 32, onto the whole width of the assembly, 26.

The process and the device, as explained up to now, are especially efficient for checking the whole of the assembly, 26, but one can envisage being faced with a substitution, which is more difficult to detect, of certain rods only in this assembly. A process that makes it possible to obtain an individual image of the fuel rods would consist in turning the device, 1, around the

assembly, 26, stopping it at certain set places and taking measurements of the activity of the assembly, 26, at each of these emplacements, before calculating the contribution of each of the rods by applying an inversion calculation of a matrix system, taking account of the distance of the rods for each measurement. Tomographic processes of this nature are however regularly used, including in the nuclear field, to such an extent that it is not useful to detail examples.

Another manner of working could consist in dedicating the measurement to a single rod or to a small number of rods. One could then adopt the system shown in Figure 7, where the casing, 2, is replaced by a composite casing, 35, composed of two concentric envelopes, an external envelope, 36, which is fitted with means for attaching it to the boom, 3, and placing it on the structure, 4, and a drive unit, 37, and an internal envelope, 38, fitted with detectors, 15 and 16, and the shield, 28. The envelopes, 36 and 38, could be mobile in relation to each other thanks to intermediate steps, 39, set out in two circles, near to the edges of the device, 1. The internal envelope, 38, could be fitted with a toothed crown, 40, which would mesh with an exit cogwheel, 41, of the drive unit, 37, so that the drive unit could turn the internal envelope, 38: one could then place the slot, 31 (or 32) vertically, in the direction of the extension of the fuel rods, in such a manner that the measured gamma radiation would only come from a single rod or a small number of rods located in the extension of the slot. The drive unit, 37, could be controlled from the outside, by a remote control or by wires, which are not shown. One could also envisage providing stop blocks to stop the movement of the internal envelope, 38, at a vertical position of the slot, 31, and at a horizontal

position of the slot, 31, and thus to limit its movement to a quarter turn; a limitation of the movement to a half turn could also be envisaged, in order to place the slot, 31, at two different vertical positions without having to move the  
5 device, 1, which is possible since the slot, 31, does not pass by the centre of the casings 36 and 38.



## CLAIMS

1. Process for discriminating nuclear fuels from their composition, whereby two types of radiation emitted by the fuel are measured, deducing the level of burn-up (TC) of the fuel from the measured value (n) of one of the types of radiation, assuming that the fuel has a defined composition, estimating an emission value for the other type of radiation as a function of the assumed composition and the level of deduced burn-up of the fuel, comparing this estimated emission value with the measured value ( $\gamma$ ) of the other type of radiation, and concluding that the assumed composition of the fuel is the real composition if the values composed are similar, and that, if not, the fuel has another composition.
2. Process for discriminating nuclear fuels according to claim 1, whereby one of the types of radiation is neutron radiation and the other type of radiation is gamma radiation over an emission energy range of at least one long life radioactive element
3. Device for discriminating nuclear fuels in an installation, comprising a structure subjacent to the storage cells immersed in a water filled bay, comprising a first detector, (15), of a first type of radiation, a second detector, (16), of a second type of radiation, a waterproof casing, (2), containing the detectors, whereby it contains the means of attaching the casing, (13, 14), to a boom, (3), that descends towards the fuel and the means of placing, (6, 9), the casing in a given position on at least one of the cells, (5), adjoining a cell containing the nuclear fuel, (26), that is the subject of the discrimination.

4. Device for discriminating nuclear fuels according to claim 3, whereby one of the detectors is a gamma radiation detector located behind two collimators in continuation (25, 31; 32, 34), comprising a rear  
5 collimator, located just in front of the said detector and opening up onto the whole detection area of a detection body, and a front collimator, with a slot section extended in the transversal direction of a fuel element.

10 5. Device for discriminating nuclear fuels according to claim 4, whereby the casing comprises a fixed part (36) bearing the means for attaching it, and a mobile part, (38), that pivots around the fixed part in such a way as to turn the slot a quarter turn or a half turn.

15 6. Device for discriminating nuclear fuels according to either claim 4 or claim 5, whereby the slot has a variable extension dimension and broadens out towards the fuel element.

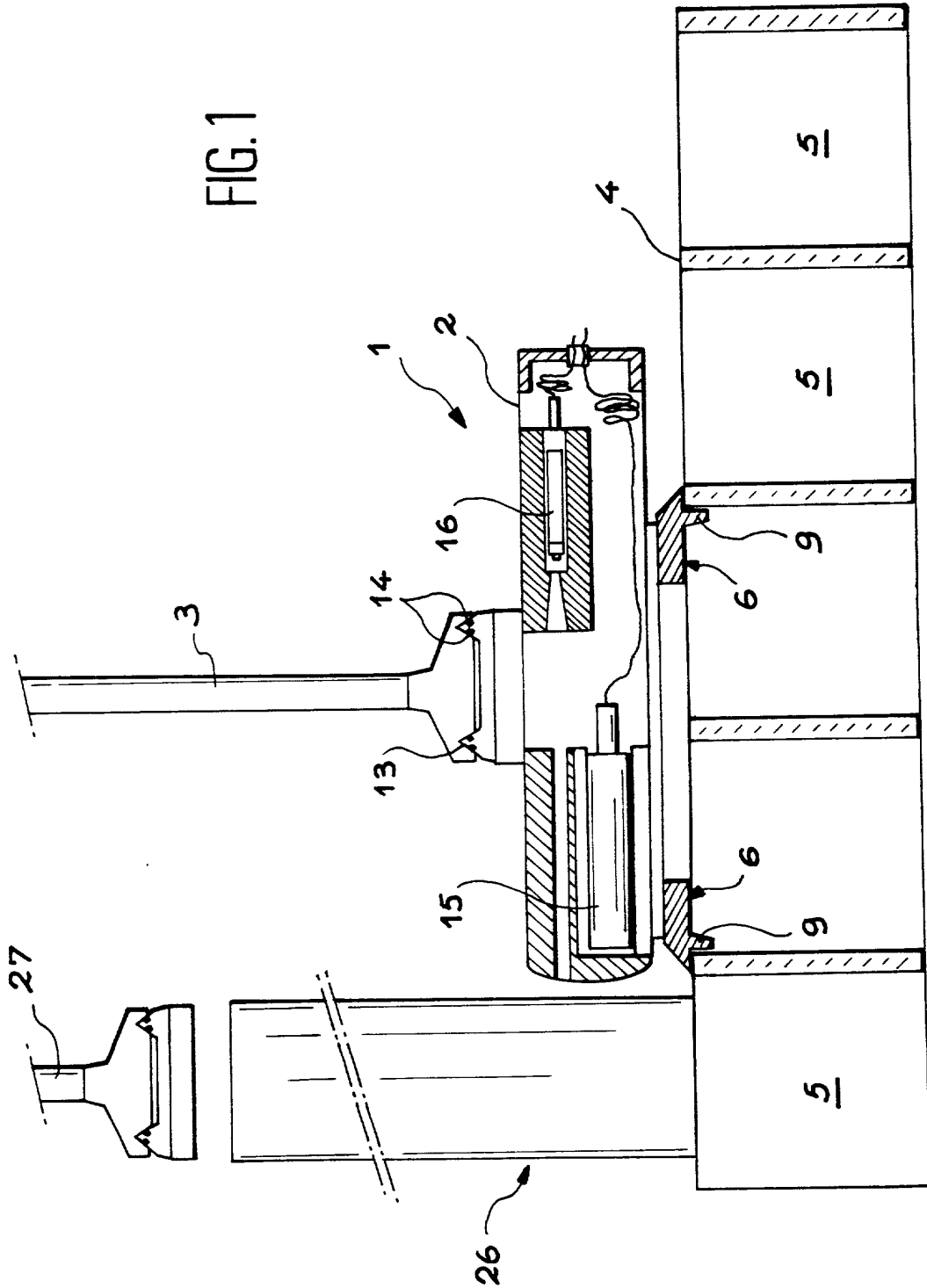
Burn up fraction

## ABSTRACT OF THE DISCLOSURE

The device comprises a detector (15) of radiation that could be neutron radiation and a detector (16) of another type of radiation, for example gamma radiation. The process consists in deducing a burn up fraction or irradiation of the nuclear fuel (26) by the measurement of the measured value of a radiation, while assuming that the fuel has a defined composition. One deduces from this the activity of the other radiation that one should obtain, and the accuracy of the assumption of the composition of the fuel if the measured value is close to this deduced value. The device (1), which makes it possible to obtain satisfactory measurements in a water filled storage bay (26), is fitted with means for attaching it to a boom (3) and for positioning it (6, 9) in a given position on a fuel storage cell structure (4). The device is displaced towards each fuel element.

Figure 1.

FIG. 1



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FIG. 2

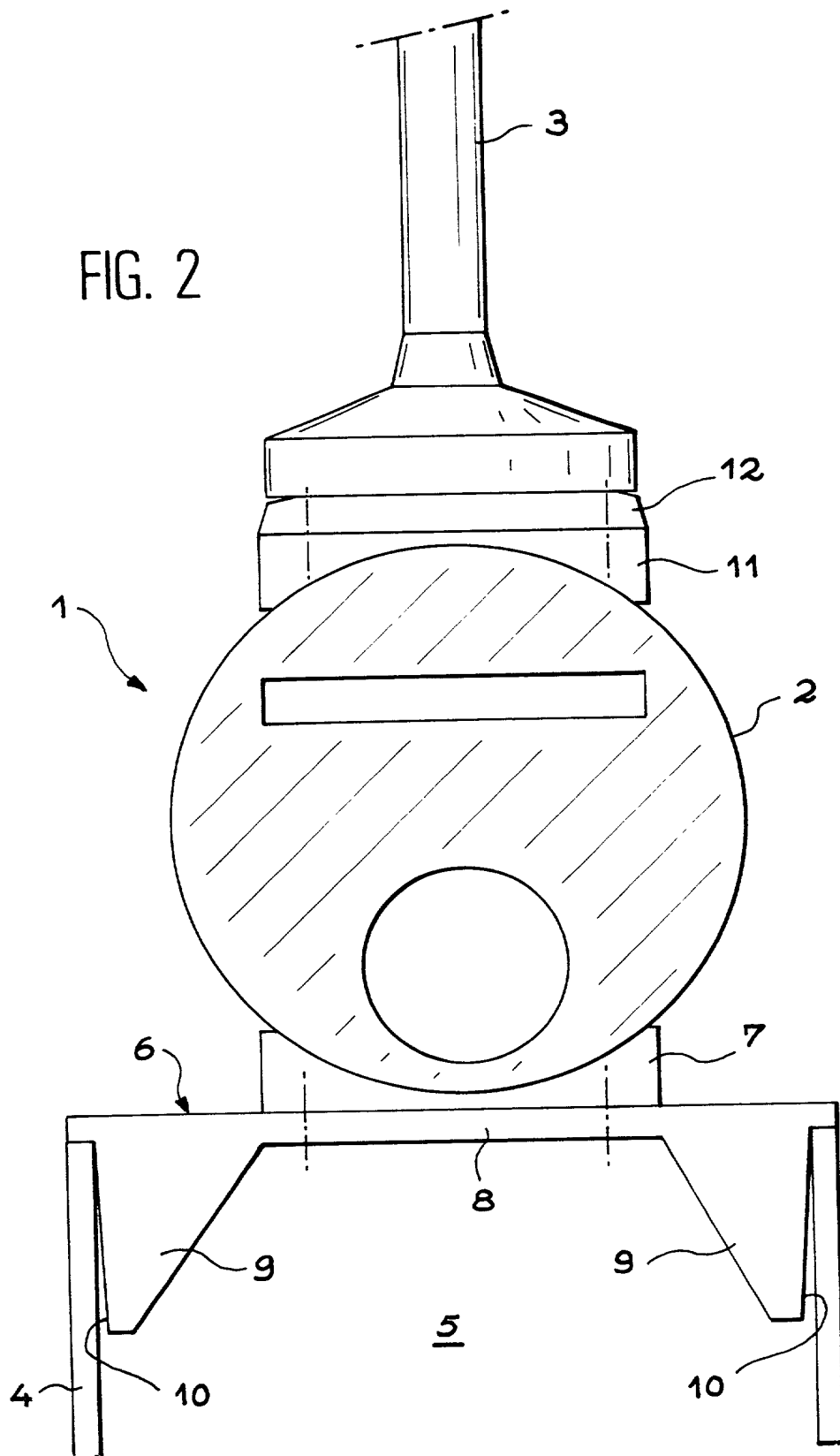


FIG. 3

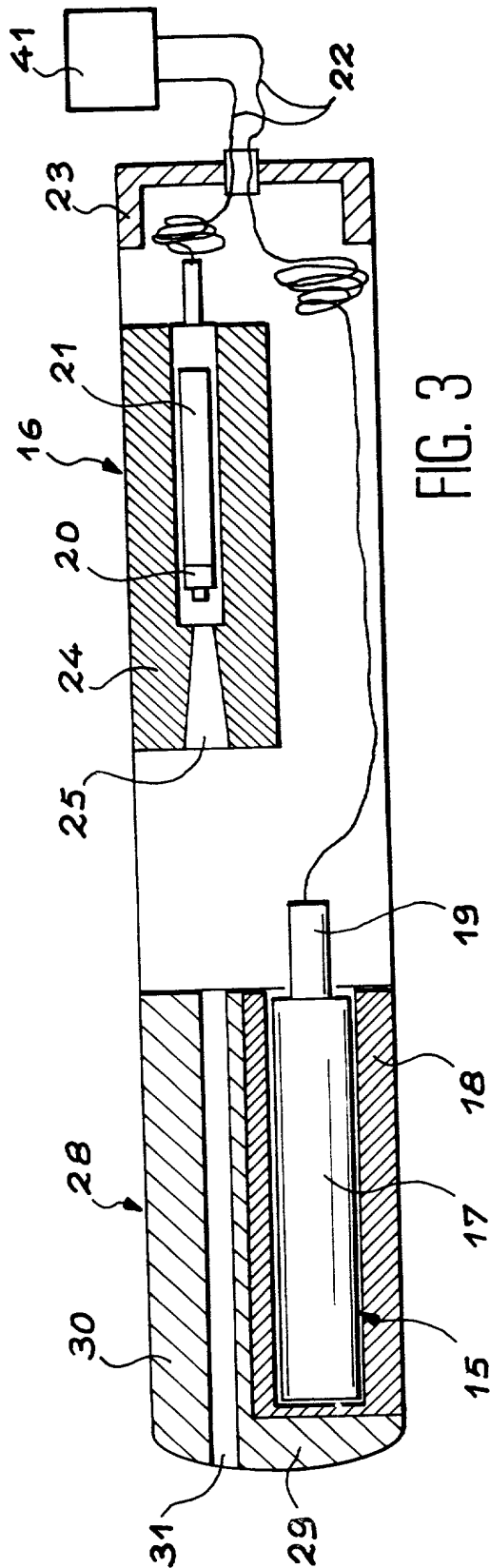


FIG. 3

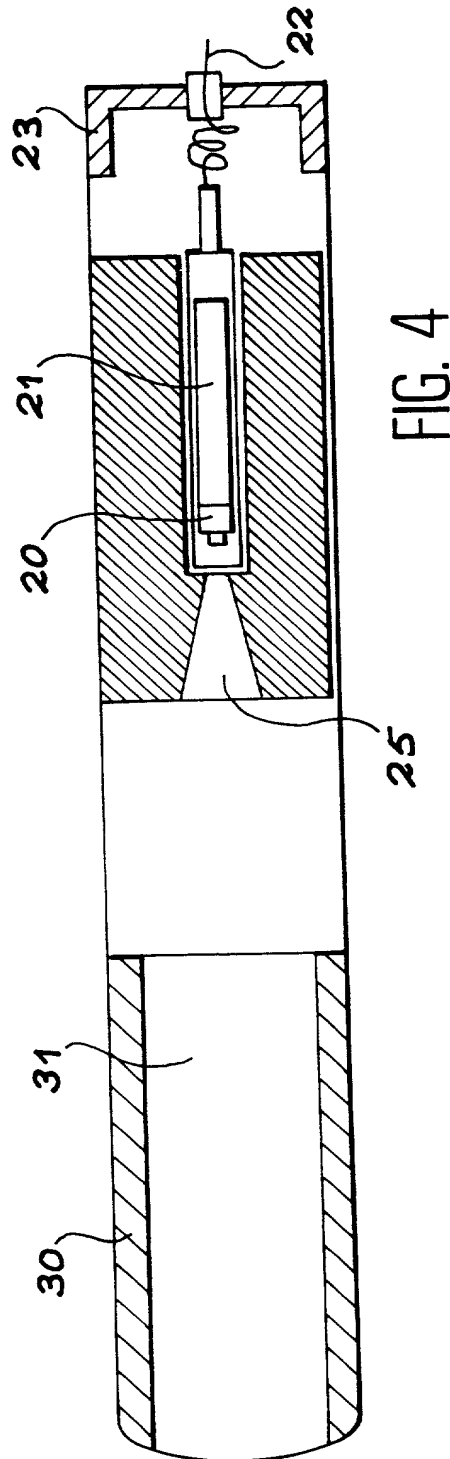
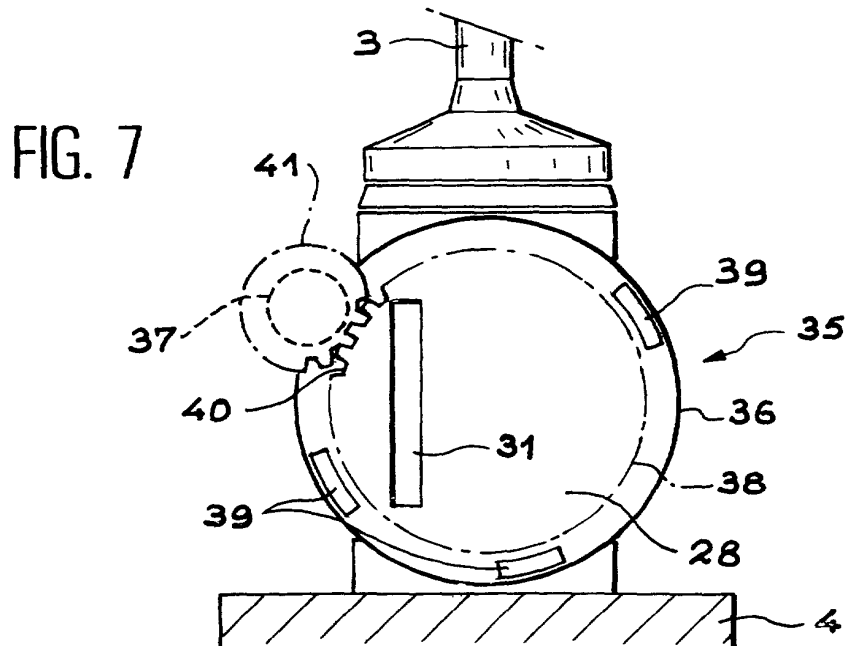
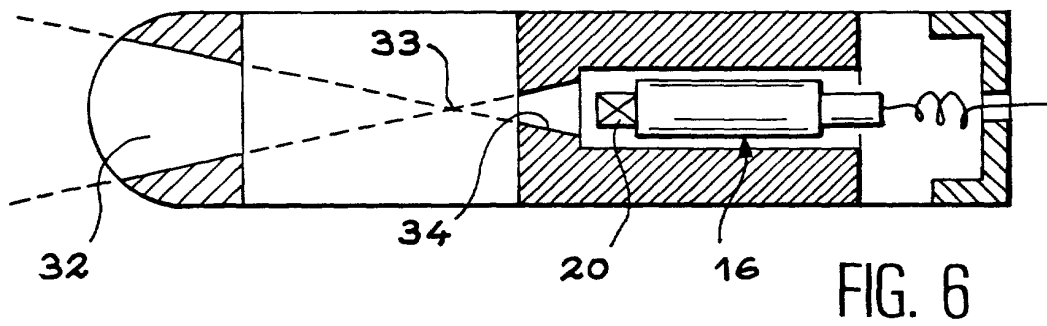
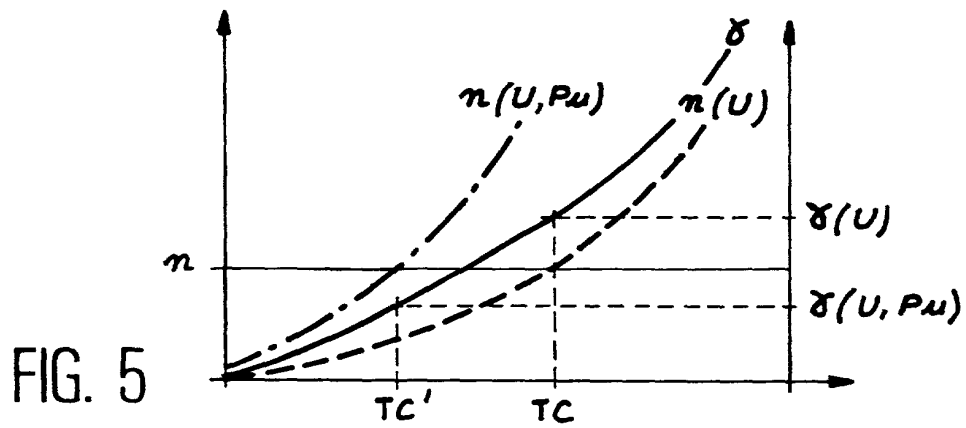


FIG. 4





# Declaration, Power Of Attorney and Petition

Page 1 of 3

WE (I) the undersigned inventor(s), hereby declare(s) that :

My residence, post office address and citizenship are as stated below next to my name,

We (I) believe that we are (I am) the original, first, and joint (sole) inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention entitled

PROCESS AND DEVICE FOR DISCRIMINATING NUCLEAR FUELS

the specification of which

- ☐ is attached hereto.
- ☐ was filed on  
as Application Serial No.  
and amended on
- ☒ was filed as PCT international application  
Number PCT/FR00/00108 ✓  
on January 19, 2000 ✓  
and was amended under PCT Article 19  
on

We (I) hereby state that we (I) have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

We (I) acknowledge the duty to disclose information known to be material to the patentability of this application as defined in Section 1.56 of Title 37 Code of Federal Regulations.

We (I) hereby claim foreign priority benefits under 35 U.S.C. § 119 (a)-(d) or § 365 (b) of any foreign application(s) for patent or inventor's certificate, or § 365 (a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed. Prior Foreign Application (s)

Application No.	Country	Day/month/Year	Priority Claimed	
99 00575 ✓	FRANCE ✓	20 JANUARY 1999 ✓	<input checked="" type="checkbox"/> YES	<input type="checkbox"/> NO
_____	_____	_____	<input type="checkbox"/> YES	<input type="checkbox"/> NO
_____	_____	_____	<input type="checkbox"/> YES	<input type="checkbox"/> NO
_____	_____	_____	<input type="checkbox"/> YES	<input type="checkbox"/> NO

We (I) hereby claim the benefit under Title 35, United States Code, § 119 (e) of any United States provisional application(s) listed below.

\_\_\_\_\_  
(Application Number)

\_\_\_\_\_  
(Filing Date)

\_\_\_\_\_  
(Application Number)

\_\_\_\_\_  
(Filing Date)

We (I) hereby claim the benefit under 35 U.S.C. §120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of prior application and the national or PCT International filing date of this application.

Application Serial No.

Filing Date

Status (pending, patented,  
abandoned)

\_\_\_\_\_

\_\_\_\_\_

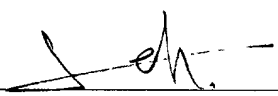
\_\_\_\_\_

And we (I) hereby appoint : Charles B. Gordon, Registration Number 16,923; William C. McCoy, Registration Number 16,885; Louis V. Granger, Registration Number 15,999; William A. Gail, Registration Number 17,409; Richard H. Dickinson Jr, Registration Number 18,622; Thomas P. Schiller, Registration Number 20,677; David B. Deioma, Registration Number 22,841; Joseph J. Corso, Registration Number 25,845; Howard G. Shimola, Registration Number 26,232; Jeffrey J. Sopko, Registration Number 27,676; John P. Murtaugh, Registration Number 34,226; James M. Moore, Registration Number 32,923; David E. Spaw, Registration Number 34,732; Michael W. Garvey, Registration Number 35,878; Paul R. Katterle, Registration Number 36,563; Richard M. Mescher, Registration Number 38,242 and Mark E. Bandy, Registration Number 35,788; our (my) attorneys, with full powers of substitution and revocation, to prosecute this application and to transact all business in the Patent Office connected therewith; and we (I) hereby request that all correspondence regarding this application be sent to the firm of PEARNE, GORDON, McCOY & GRANGER whose Post Office Address is : 526 Superior Avenue east Suite 1200 Cleveland, Ohio 44114-1484.

We (I) declare that all statements made herein of our (my) own knowledge are true and that all statements made on information and belief are believed to be true ; and future that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such wilful false statements may jeopardise the validity of the application or any patent issuing thereon.

1-00 LEBRUN Alain

NAME OF FIRST SOLE INVENTOR

  
Signature of Inventor

June 23, 2001

Date

Residence : 10 Impasse du Rouge

Caye  
13490 SOUQUES FRANCE FRX

Citizen of : FRANCE

Post Office Address : The same as residence

200 BIGNAN Gilles

NAME OF SECOND INVENTOR

Signature of Inventor

June 23, 2001  
Date

Residence : 56 pr<sup>e</sup> de ville -

13650 PEYRARGUES  
FRANCE FRX

Citizen of: FRANCE ✓

Post Office Address : The same as residence

300. VAUBAILLON. Sylvain

NAME OF THIRD INVENTOR

Signature of Inventor

Date June 23, 2001

Residence : H av. S. BOLIVAR

75019 Paris FRX  
FRANCE

Citizen of: FRANCE

Post Office Address : The same as residence

NAME OF FOURTH INVENTOR

Signature of Inventor

Date \_\_\_\_\_

Residence : \_\_\_\_\_

Citizen of :

Post Office Address : The same as residence

NAME OF FIFTH INVENTOR

Signature of Inventor

Date \_\_\_\_\_

Residence :

Citizen of :

Post Office Address : The same as residence